

Radio-Linked Caller Identification System

With up to 16 caller units

By Dr. Pei An

pan@intec-group.co.uk

This article introduces a PC-based radio-linked caller identification system. It consists of a central receiver and up to 16 caller units. The receiver is connected to a computer via the Centronics port. Each unit has a push-to-make button on it. When the button is pressed, the caller unit sends out a unique code to the soundings. The receiver intercepts the code and the computer decodes it and displays the number of the activated caller unit on the screen. The operation distance is about 75 metres in buildings and 200 metres in open fields.



The system has a wide range of applications. In hotels, restaurant and shops, the caller unit can serve as a 'Call Assistance' button used by customers to call for assistance. It also has applications in interactive teaching environment in schools and colleges.

The system utilises '2nd generation' versions of FM radio transmitter and receiver modules (TX2/RX2) from Radiometrix Limited. The transmitter is a low-power device (LPD) type-approved to the Radiocommunications Authority (RA) specification MPT 1340 in the UK and Europe. This avoids the need to submit the project for final approval.

A Visual Basic 5 program has been developed for the system, demonstrating how the system is integrated with software.

How it works

Figure 1a shows the principle of the caller unit. Inside a caller unit (transmitter), an encoder IC (HT-12E) converts a 12-bit parallel data into serial data. The first eight bits represent a *system address* and the next 4 bits are the *address of the caller unit*. The system address ranges from 0 to 255 and is a value assigned to the system. The address of a call unit ranges from 0 to 15. The serial data is fed into the Radiometrix TX2 radio transmitter module, in which the serial data modulates a radio frequency carrier signal (at 418 MHz or 433 MHz, depending on the TX2 version used) using FM modulation. Next, the radio signal is transmitted to surroundings from an antenna.

The basic operation of the system receiver is illustrated in **Figure 2b**. Inside a receiver, an FM radio receiver module (RX2) demodulates the radio signal picked up by the antenna. Once demodulated, serial data is fed into a serial-to-parallel decoder IC (HT-12D), which converts the serial data back to parallel format. The address bits are compared with the preset address of the decoder. If they match, the 4-bit data is latched to the output (which is the address of the activated caller unit). If the address does not match, the decoder ignores the data. After a dataword is successfully received, the computer reads the data from the decoder and displays the number of the activated caller unit on the screen.

Radio transmitter and receiver modules

The Radiometrix radio transmitter and receiver modules (TX2 and RX2) allow a digital radio link to be implemented easily. The modules are a SAW-controlled FM radio transmitter and receiver which are specially designed for radio telemetry and tele-command applications (SAW = surface acoustic wave). There are a variety of TX2/RX2 modules that can be used with the present project. They are shown in **Table 1**.

A brief description of the transmitter and receiver modules is given here. Technical details of the modules can be found in the data

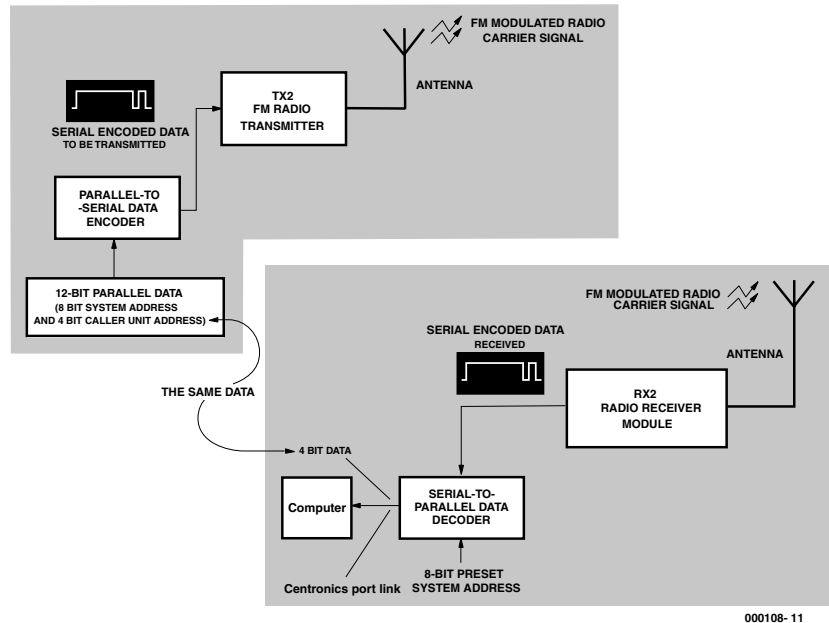


Figure 1. Principle of the Caller Identification system.

Table 1 Variant of TX2/RX2 radio link modules

Parameters	Description
Frequencies	418.00 MHz for UK use 433.92 MHz for European use
Supply voltages	5V (4-6V for TX2 and RX2) 3V (2.2V to 4V for TX2, 3 to 4V for RX2)
RX data transfer rate	-A: 7kHz baseband BW, slow data up to 14kbps -F: 20kHz baseband BW, fast data up to 40kbps

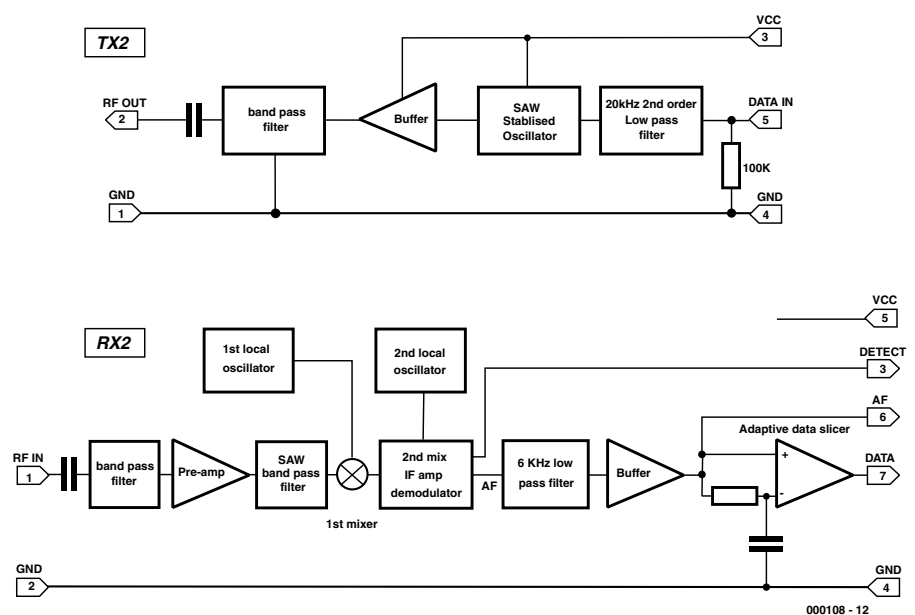


Figure 2. Internal block diagram of the radio link modules.

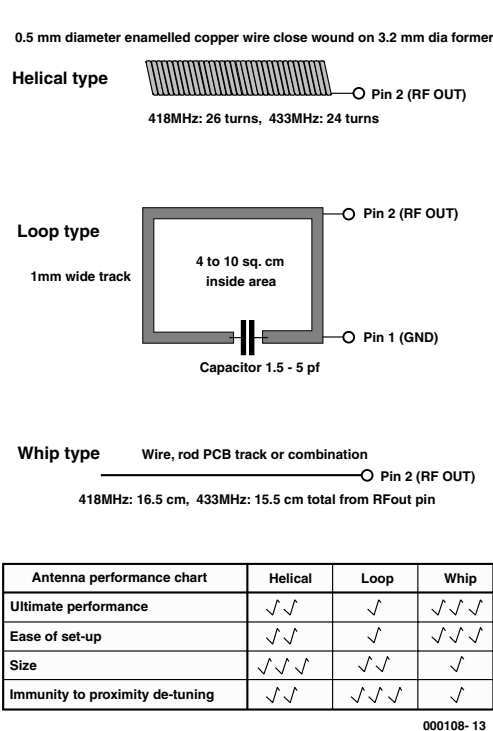


Figure 3. Antennas for the radio link modules.

sheets, Reference [1].

Transmitter Module type TX2

The pin functions of the transmitter are given in **Figure 2a**. For the +5 V and 433 MHz version, the operation voltage ranges from 4 to 6 V DC. The typical current consumption is about 10 mA at 5 V. For the +3 V and 433 MHz version, the operation voltage is between 2.2 V to 4 V DC with a typical current consumption of 6 mA at 3 V. Digital data to be sent (which should be a CMOS logic level at the same power supply voltage) is fed into pin 5. An antenna is connected to pin 2. The block diagram of the module is given in **Figure 2a**.

Receiver Module type RX2

The pin functions of the receiver are shown in **Figure 2b**. For the +5 V version, the operation voltage ranges from 4 to 6 V DC. The typical current consumption is about 13 mA at 5 V. For the +3 V version, the operation voltage is between 3.0 to 4.0 V DC

with a typical current consumption of 13 mA at 3.5 V. The output digital signal appears at pin 7 (RXD) with a CMOS logic level. Pin 3 is the Carrier Detect output. It may be used to drive an external pnp transistor to obtain a logic level carrier detect signal. If not used, it should be connected to +5 V.

Antenna options

The antenna used with an LPD like the TX2 module is usually one of three versions: the helical type, the loop type and the whip type (see **Figure 3**). The helical antenna has a small size. It needs to be optimised for the exact wavelength in use. The loop antenna consists of a loop of PCB track, which is tuned by a variable capacitor. The quarter-wave whip-type antenna is a length of wire, a rod, a PCB track or combinations. **Figure 3** shows how the different versions are constructed and compares the performance amongst various antennas. The above

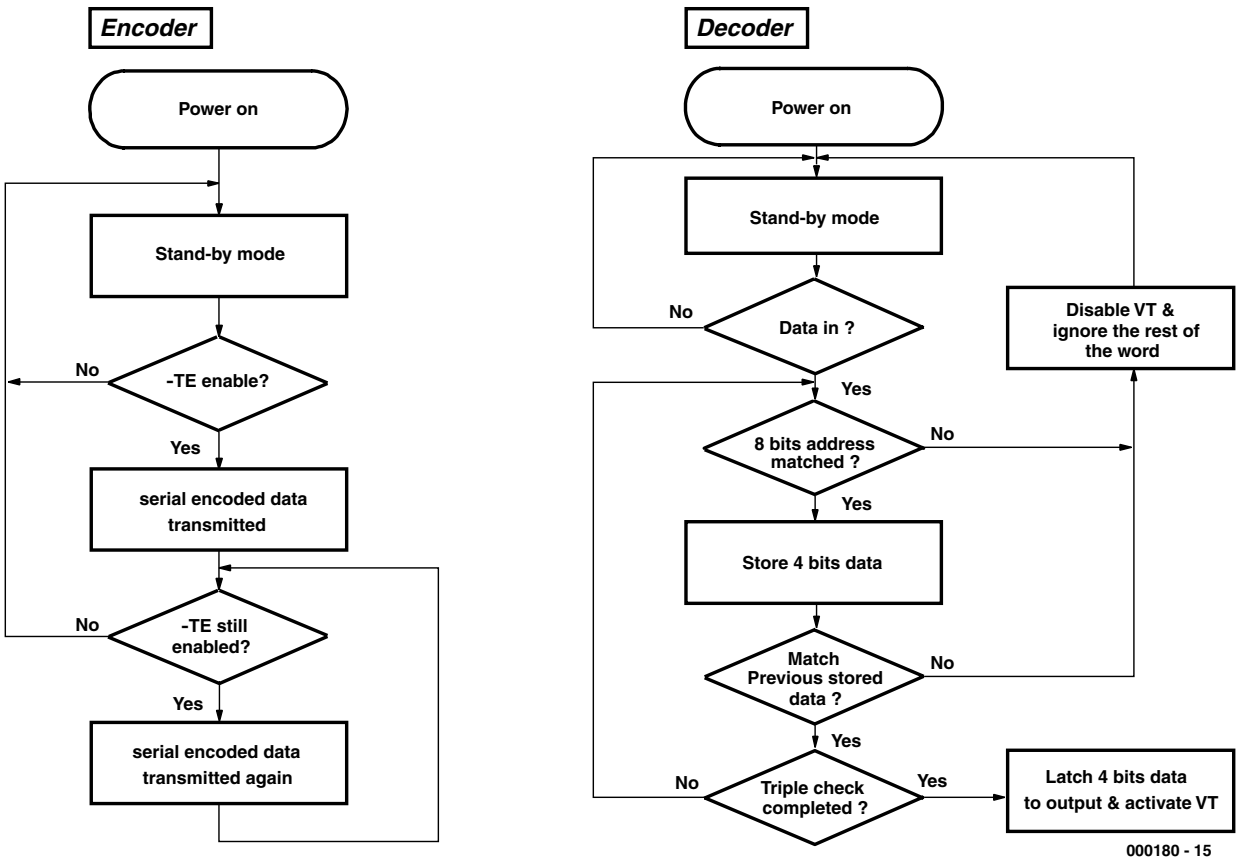


Figure 4. Flow charts of encoder and decoder operation.

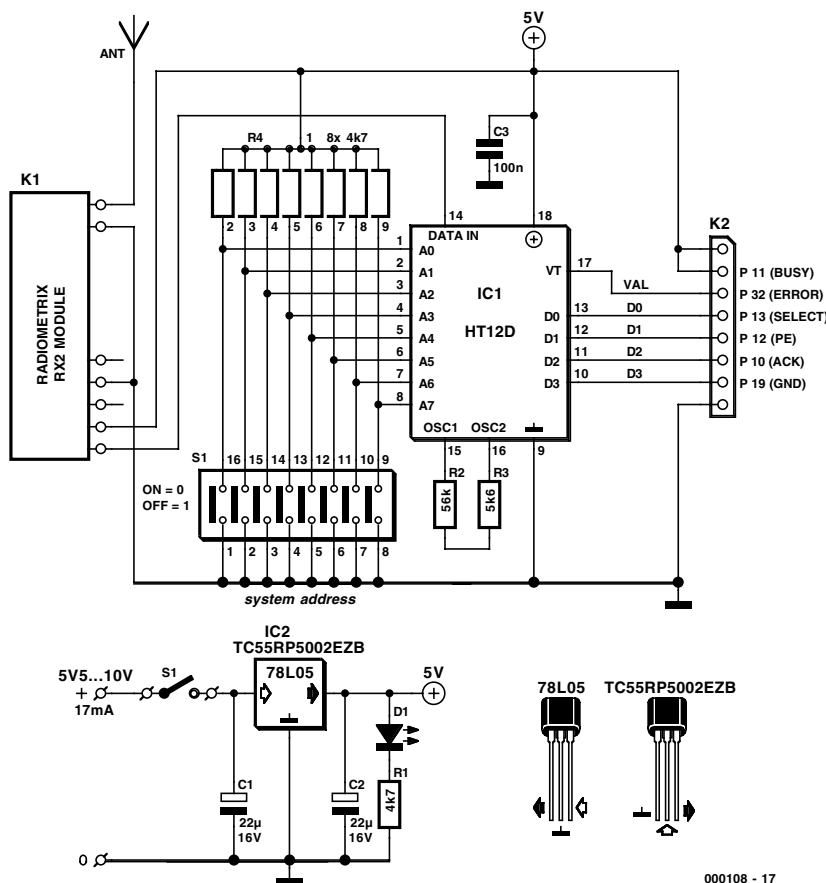


Figure 7. Circuit diagram of the central receiver unit.

Table 2. Some values of external resistors for encoder and decoder.

HT-12E (encoder)		HT-12D (decoder)	
R	F _{osc}	R	F _{osc}
1.1 M	3 kHz	62 k	150 kHz
750 k	4.3 kHz	33 k	240 kHz

the encoder is determined by the logic states at pins 1-8 for A0-A7. The latched data is output from pins 10 to 13. The serial data is input at pin 14. The external oscillator resistor is connected between pins 15 and 16. Pin 17 is the valid transmission (VT) indicator output. The external resistors required on the OSC pins of the HT12D/E are 1% types. **Table 2** gives the resistance values for 3 kHz and 4.3 kHz clock frequencies, F_{osc} (in the present circuit, $F_{osc} = 3 \text{ kHz}$). For other frequencies, please refer to the manufacturer's data sheet.

Circuit of caller unit

Figure 6 shows the circuit diagram of the transmitter. The encoder, HT-12E, converts an 8-bit address (system address set by DIP

switch block S1) and a 4-bit data (caller address set by DIP switch block S2) into a serial data form. The serial data is output from the Dout pin, number 17. The $\overline{\text{TE}}$ input (Transmit Enable, pin 14) is set permanently to Low to enable data transmission.

The serial data generated by the HT-12E encoder is fed into pin 5 of the TX2 radio transmitter module which is plugged or soldered onto connector K1. The transmitter signal emerges from pin 2 of the TX2 module and is radiated by an antenna.

The power supply to the caller unit is an N-type 12-V alkaline battery (10 mm diameter and 28 mm

length, 33 mAh capacity). The voltage is regulated to +5 V by a low-power and low-drop voltage regulator type TC55RP5002EZB from Telcom. Alternatively, an 78L05 may be used, but unlike the Telcom IC it will not allow the battery voltage to drop to 5.5 V before the transmitter becomes inoperative. Also note the different pinouts of the two regulators! S3 is a push button switch (push to make type). If the button is not pressed, no voltage is supplied to the circuit. If it is pressed, the caller unit immediately transmits the code. This arrangement allows a maximum battery power saving to be achieved. During a transmission, current consumption is about 15 mA. A calculation indicates that an N-type battery will last 2.3 hours of data transmission. Assuming that the activation time of switch is 1 second on average, the battery will last for at least 2,300 calls.

COMPONENTS LIST

Caller Unit (TX)

Resistors:

R1,R2 = 1M Ω 1%
R3 = 4k Ω 7
R4 = SIL array, 8-way, 10k Ω
R5 = SIL array, 4-way, 10k Ω

Capacitors:

C1,C2 = 22 μ F 16V radial
C3,C4 = 100nF, 5mm lead pitch
C5 = 100pF

Semiconductors:

DI = LED, high efficiency
IC1 = HT-12E (Holttek), RS
Components # 854-100, Maplin
AE17T, Conrad # 175420
IC2 = TC55RP5002EZB, RS
Components # 207-0045

Miscellaneous:

K1 = Transmitter module,
RadioMetrix type TX2, Farnell #
722-4930 (418 MHz) or 722-
4953 (433 MHz)*
S1 = 8-way DIP switch
S2 = 4-way DIP switch
S3 = pushbutton, I make contact
Antenna, see text
BT1 = 12V N-size battery (L1028)
PCB, order code **000108-I** (see
Readers Services page)
ABS case, size 124 x 33 x 30 mm,
Maplin # FT311

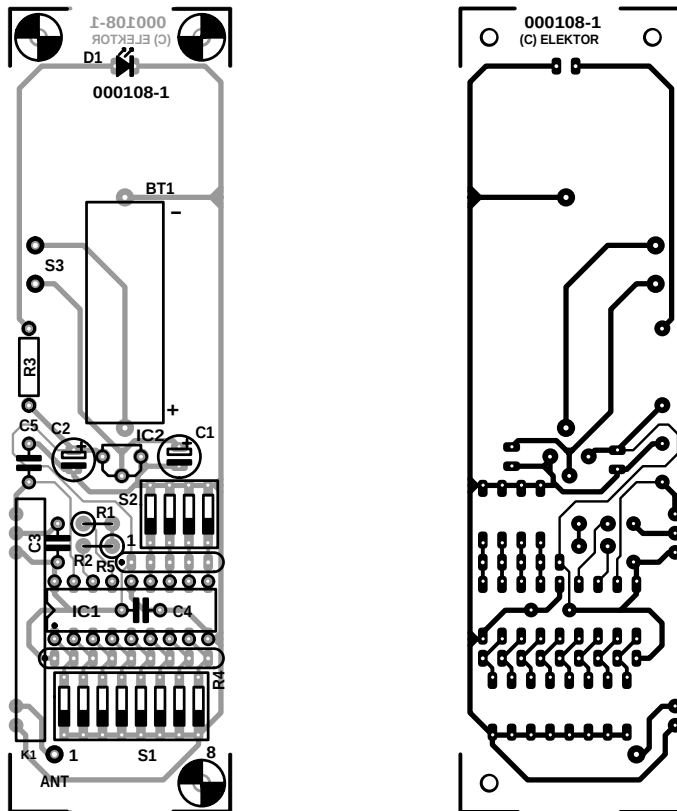


Figure 8. Track layout and component mounting plan of caller PCB (board available ready-made).

Circuit of receiver unit

Figure 7 gives the circuit diagram of the central receiver. The radio frequency signal is picked up by an antenna and is fed into pin 1 of the RX2 receiver module. The demodu-

lated signal is output from pin 7 and is fed into the decoder IC via pin 7 of connector K1.

The HT-12D decoder chip receives the serial data at pin 14, checks for errors and outputs the received data

if it is a valid transmission. The first eight bits are treated as address bits and must match the pre-set address of the decoder (set by DIP switch array S1). If the two addresses match, the next four data bits are compared with the last data stored. If the data matches three times, the Valid Transmission output (pin 17) will go high. If not, VT remains low.

The supply voltage is regulated to +5 V by a low-power and low-drop voltage regulator, TC555RP500. Alternatively, a 78L05 may be used.

The printer status lines of a Centronics port are used to read data into the computer. The four data outputs from the HT-12D (D0-D3) and the VT (Valid Transmission) output are connected to the five input lines (bits 3-7) of the status port. More details on the Centronics port and its applications may be found in Reference [3].

Because the receiver has to be on all the time to receive calls from caller units, it is

COMPONENTS LIST

Receiver Unit (RX)

Resistors:

- R1 = 4k Ω 7
- R2 = 56k Ω 1%
- R3 = 5k Ω 6 1%
- R4 = 8-way SIL array, 4k Ω 7

Capacitors:

- C1, C2 = 22 μ F 16V radial
- C3 = 100nF

Semiconductors:

- D1 = LED, high efficiency
- IC1 = HT-12D (Holtek), RS Components # 854-116, Maplin # AE18U, Conrad # 174351
- IC2 = TC555RP5002EZB, RS Components # 207-0045

Miscellaneous:

- K1 = Receiver module, RadioMetrix type RX2, Farnell # 722-4941 (418 MHz) or 722-4965 (433 MHz)*
- K2 = 8-way SIL pinheader
- S1 = 8-way DIP switch
- S2 = on/off switch
- Antenna, see text
- ABS case, size 125 x 62 x 38 mm, Maplin # BZ73Q
- PCB, order code 000108-2 (see Readers Services page)
- Disk, project software, order code 00108-11 (see Readers Services page)

* Radiometrix distributor for the UK: Low Power Radio Solutions (LPRS), <http://www.lprs.co.uk>

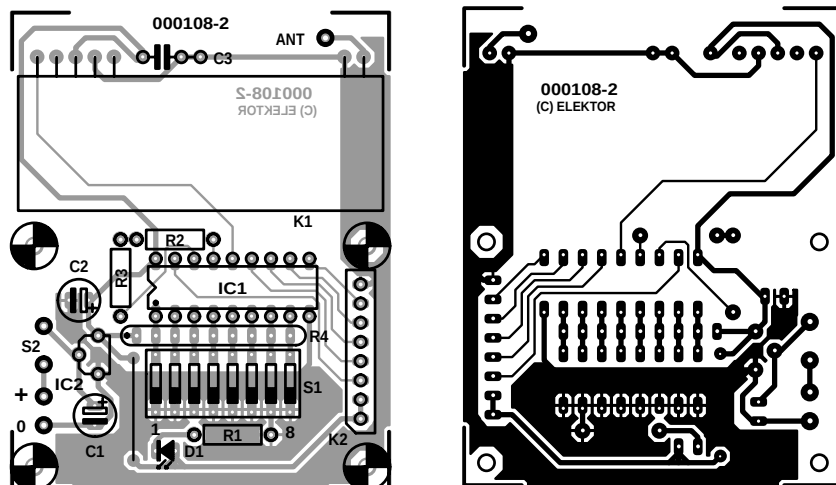


Figure 9. Track layout and component mounting plan of receiver PCB (board available ready-made).

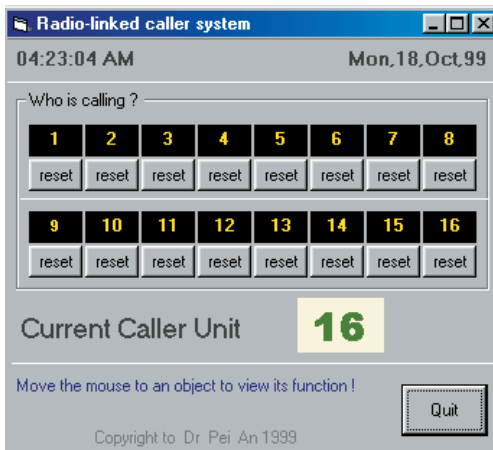


Figure 10. Screenshot of the 'Call Centre' software which runs under Windows.

powered by a small mains adaptor with an unregulated output voltage between about 6 V and 10 VDC.

Construction

The caller and receiver are constructed on single-sided PCB boards (Figures 8 and 9).

The helical antenna of the receiver is constructed using a piece of copper wire (see Figure 3 for construction details).

The parts lists suggest plastic (ABS) cases that may be used for the transmitter and receiver units. These cases pass RF signals at 70 cms and so allow the antennas to be incorporated. If the boards are mounted in metal cases, the antennas should not be enclosed. In most cases, that will leave the quarter-wave whip as the only viable option.

Construction of the caller and receiver units is rather simple. After soldering all the components on the PCB boards properly, and setting the DIP switches, the system will work straight away. Actually, the only thing you have to be careful with is the mounting of the voltage regulators as the 78L05 and TC55RP500 have **different pinouts**. There is no adjustment needed for the caller units and the receiver. Photographs of our prototypes are shown in **Figures 11 and 12**.

Software driver

The receiver is coupled to a programs that runs on a PC. The software driver is written in Visual BASIC 5. Readers should have some degree of knowledge about the Centronics port in order to understand the following description of the system software.

Bit 3 through to bit 7 of the Status port read data from the decoder. Bit 7 is connected to VT output of the decoder. When no transmission is received, VT remains low. When one of the caller units is activated and a valid transmission is received, VT ramps high. It remains high until the caller unit is no longer activated. So by polling this line at a regular interval, the computer will know if a caller unit is activated. Then, the computer reads data A0-A3 through bits 3-6 of the Status port. A0-A3 are the address bits of the most recently activated caller unit.

The operation of the software driver is illustrated in **Figure 10**. On the screen, there are 16 boxes corre-

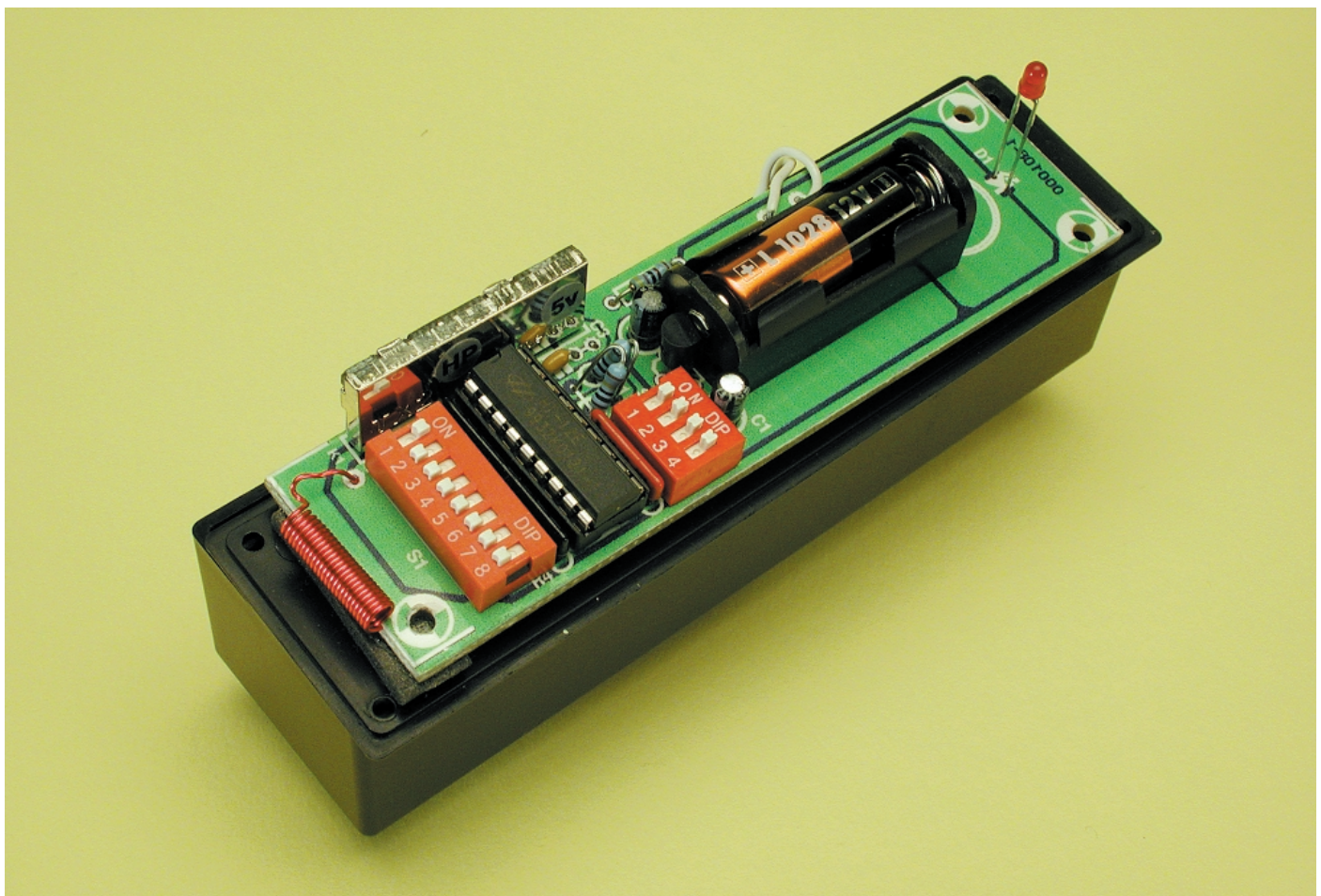


Figure 11. Completed caller board.

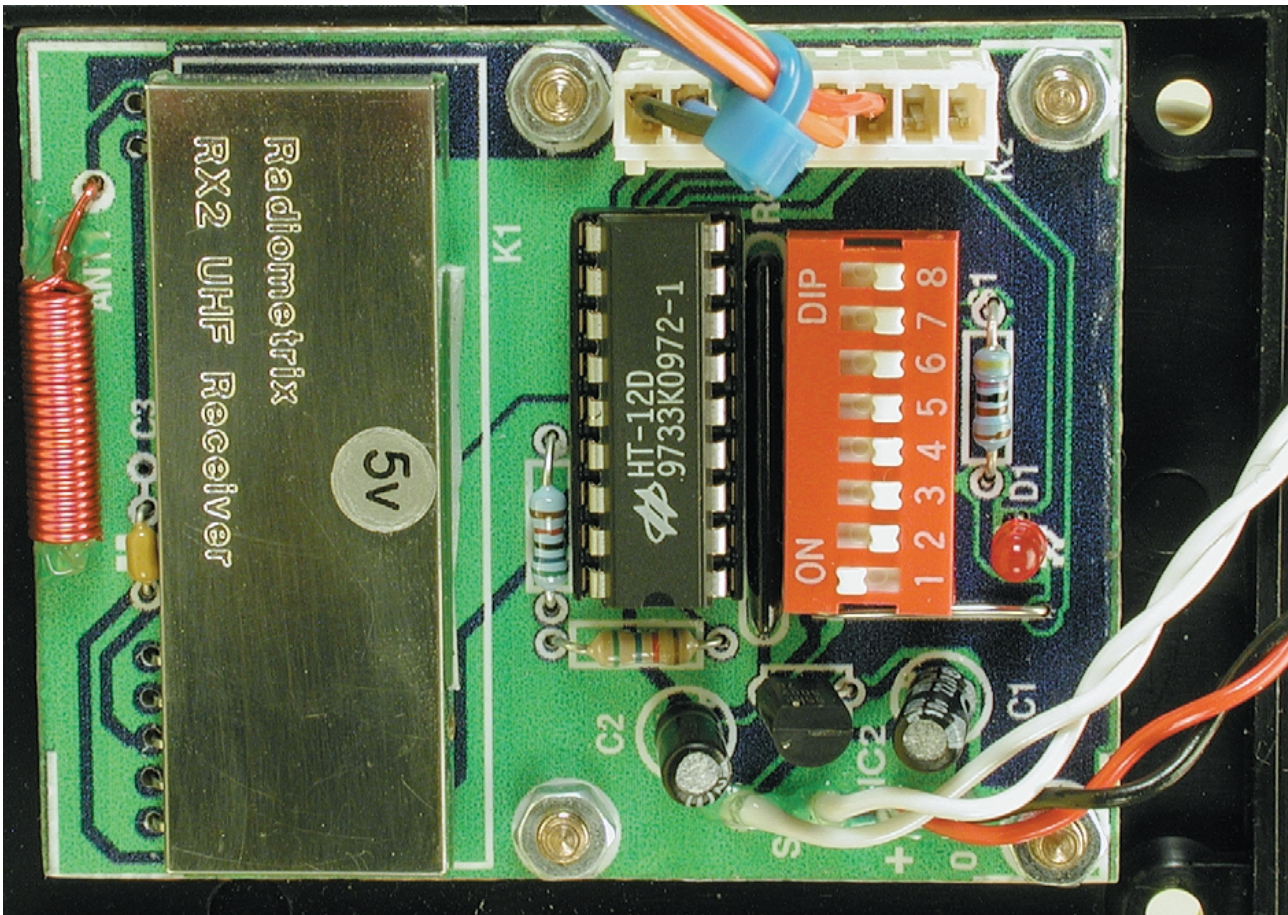


Figure 12. Completed receiver board.

sponding to Caller unit 1 to Caller unit 16. If a caller unit has never been activated, the box is black. If the caller unit is activated, the box becomes red to indicate that there is a call from that caller unit. Click the 'reset' button below the box to clear the call (box becomes black). The address of the most recently called unit is also shown on the screen.

It is known that VB5 is unable to read data directly from a hardware port. Therefore, a DLL I/O function is used. The DLL library is called `iosys.dll` and is written in Visual C. The I/O function (`inport`) should be declared in the `Callersys.bas` module first, then it can be called elsewhere in the program. This DLL, along with all software for the project, is available on a diskette set, order code **000108-11**. All project software is also available from the Free Downloads section of our website at <http://www.elektor-electronics.co.uk>. Look for item # 000108-11 under January 2001.

(000108-1)

Acknowledgement

The author expresses his gratitude for the help he received from Mr. Kangeyan at Radiometrix Ltd.

References

1. Datasheets for TX2 and RX2, available from Radiometrix Ltd. Tel. (+44) (0)1814 281220. Website: <http://www.radiometrix.co.uk>
2. Data sheets for HT-12 series from Holtek. Website: <http://www.holtek.com.tw>
3. PC Interfacing - Using Centronics, RS232 and game ports, Pei An, Newnes, Butterworth-Heinemann, 1998, ISBN 024 0514 483

On Project disk set 000108-11a/b/c/

Diskette 000108-11a

AsycFilt.dll
Contents.txt
Copyright.txt
MSVBVM50.dll_
OlePro32.dll_
Setup.exe
Setup.lst
setup1.ex_
St5unst.ex_
StdOle2.tl_
VB5StKit.dll_

Diskette 000108-11b

AsycFilt.dll2
ComCat.dll_
Contents.txt
Copyright.txt
Ctl3d32.dll_
iosys.dll_
MSJet35.dll_
MSJInt35.dll_
MSJtEr35.dll_
MSVCRT40.dll_
VB5DB.dll
VBAJet32.dll_

Diskette 000108-11c

Callsys.ex_
Contents.txt
Copyright.txt
Dao350.dll_
MSRD2x35.dll_
MsRepl35.dll_
ODBCJ132.dll_
ODBCJt32.dll_
ODBCCTL32.dll_
OleAut32.dll_
VB5DB.dll2